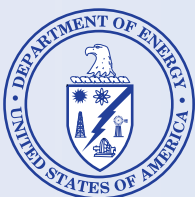


Vision 21



**Clean Energy
for the 21st Century**



Vision 21

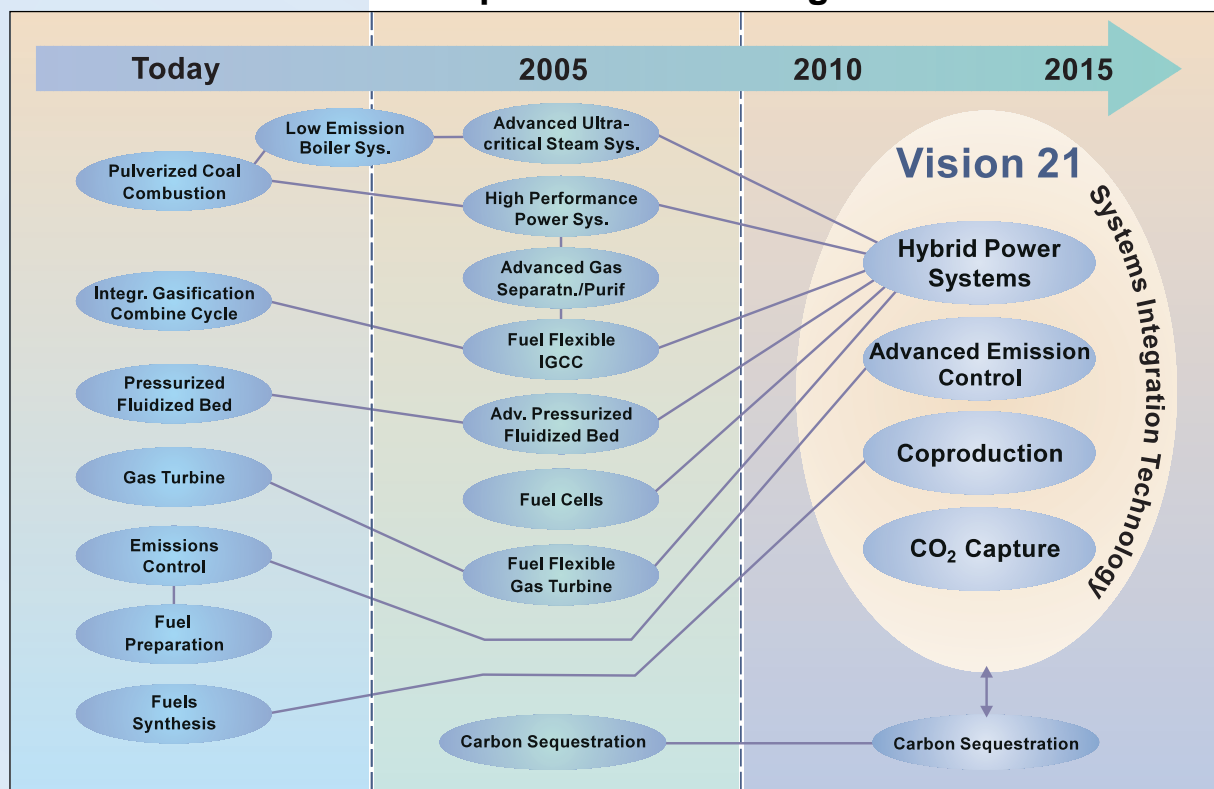


**Clean Energy
for the 21st Century**

The Challenge

Protecting the environment by meeting or surpassing tightening environmental standards and producing the plentiful supply of low-cost energy essential to economic growth — these are the dual concerns that challenge the coal and power systems research and development community as we enter the 21st century. The U.S. Department of Energy (DOE) Office of Fossil Energy (FE) and Federal Energy Technology Center (FETC) are meeting the challenge through *Vision 21*.

Roadmap for Vision 21 Program



What is Vision 21?

The availability of abundant, low cost fossil fuels has been a cornerstone of U.S. energy and economic strength. The continuing future utilization of fossil fuels in the U.S. – and quite likely, throughout much of the world – will be shaped by environmental considerations and technological innovation. The Department of Energy has reoriented its ongoing R&D program to focus on developing a suite of technologies that would eliminate any environmental concerns associated with the use of fossil fuels while assuring the continuing availability of low cost energy to fuel our economy and to enhance our quality of life. The Department has called this program Vision 21. The Vision 21 program, which has been endorsed by the President's Committee of Advisors on Science and Technology, is a long-range, cost-shared, gov-

ernment-industry-academia partnership designed to produce public benefits beginning within a decade and extending well into the next century.

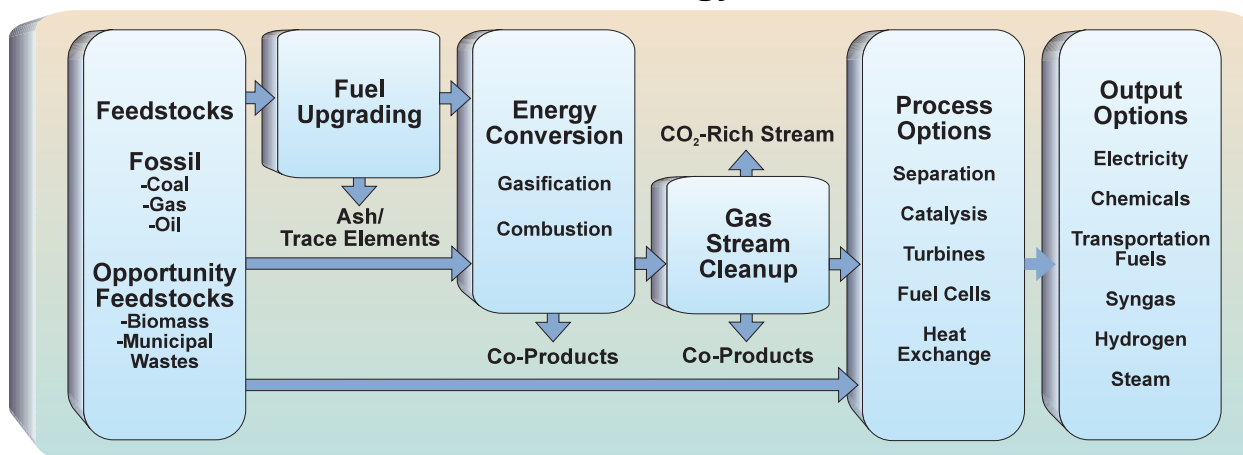
The Vision 21 program will integrate emerging concepts for high-efficiency power production and pollution controls into a new class of fuel-flexible electricity generation facilities. It will also offer a “market-entry” strategy for new concepts to produce high value fuels and chemicals from coal and other feedstocks. Discrete technology modules will offer future plant designers maximum flexibility in their choice of products, feedstocks, and environmental controls. Planners will be able to select modules according to feedstock supply and product demands of an individual region.

The Vision 21 plants will greatly reduce the energy intensity of the economy through dramatic generation efficiency improvements with virtually no environmental impact. Conventional pollut-

ants could be captured and either disposed of or converted to marketable co-products. Creation of carbon dioxide and other greenhouse gases would be reduced by ultra-high efficiency technologies; then carbon emissions could be captured at the plant or offset by carbon removal processes applied elsewhere. The captured carbon could be sequestered or potentially recycled into useful products.

At the core of a Vision 21 plant would be power generation; but rather than being limited to a single feedstock producing a single product, such a complex would be capable of processing coal, natural gas, biomass, or a combination into a range of products. In its ultimate configuration, electric power could be only one – albeit the most significant – of a slate of products that would also include liquid fuels and chemicals along with process heat. The exact mix of feedstocks and products would be dictated by site-specific market considerations.

Vision 21 Technology Modules



The Vision 21 Plant

The primary goal of Vision 21 is to develop the technology basis for ultra-clean integrated energy plants that will be deployed early in the 21st century. These plants will utilize advanced technology modules that can be integrated and configured to create power generation systems tailored to specific energy markets. In a Vision 21 setting, advanced turbines, gasifiers, fluidized beds, high-temperature combustion systems, or fuel cells would be used to generate

power. Early versions of these technologies have entered the commercial market; DOE-funded research will accelerate the advancements needed for Vision 21 applications.

Because Vision 21 plants could be customized, they could better respond to specific needs of local markets. For example, one plant may be equipped to produce electricity utilizing low-cost opportunity fuels. Another plant may be tailored to co-produce electricity along with low-priced chemical feedstocks in regions where there is a market demand for a specific feedstock for chemical processing plants.



Characteristics of Vision 21 Plants

Vision 21 Plants Will:

- ✓ Combine high-performance subsystems with smart systems-integration techniques.
- ✓ Use feedstocks that include fossil fuel.
- ✓ Be a net electricity producer.
- ✓ Have high efficiency, low emissions, and competitive cost.

Vision 21 Plants May:

- ✓ Incorporate modular subsystems and components using standardized designs.
- ✓ Utilize “opportunity” feedstocks.
- ✓ Deliver opportunity products.
- ✓ Capture CO₂ for sequestration.

Vision 21 Benefits

Vision 21 is essential to generating electricity in the 21st century while meeting environmental requirements, and keeping energy costs affordable and consistent with robust economic growth. An aggressive government/industry cost-shared Vision 21 program would:

- **Remove environmental barriers to fossil fuel use.** Environmental barriers, including smog- and acid-rain-forming pollutants, and particulate and hazardous air pollutants, are effectively removed. Solid waste is eliminated by its conversion to useful products. Concerns over global climate change are mitigated by reductions in CO₂ emissions of up to 50 percent. Net CO₂ emissions can be reduced to practically zero through sequestration.
- **Keep energy costs affordable.** Without the technological innovations brought about by a Vision 21 program, use of low-cost fossil fuels is likely to be severely curtailed by environmental pressures, particularly global climate change concerns. This will leave the U.S. with a substantially narrowed range of much higher cost energy options, which may limit the

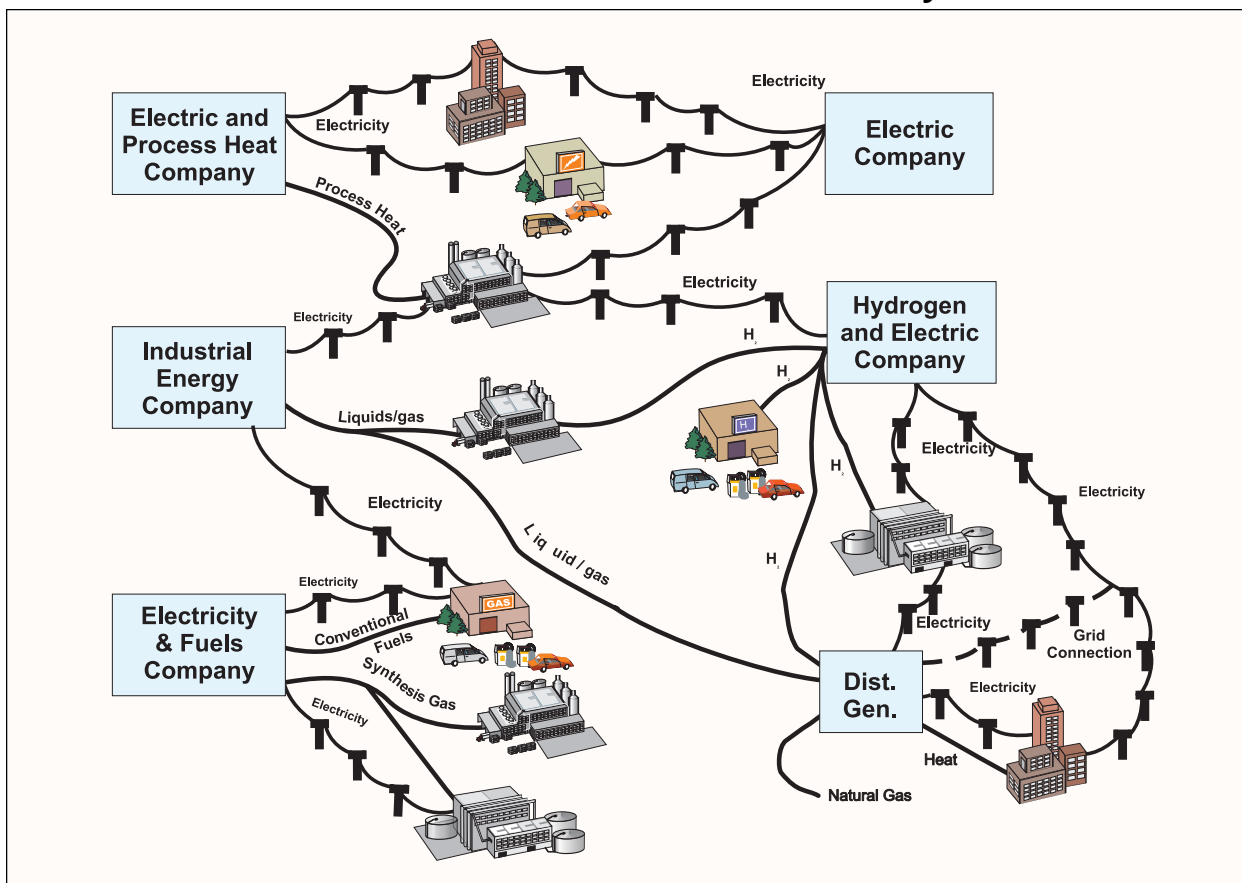
full potential for achieving sustained economic growth and prosperity.

- **Produce useful co-products, including liquid transportation fuels.** Vision 21 can produce environmentally superior liquid transportation fuels that are cost-competitive with equivalent petroleum products. This capability would reduce our reliance on imported oil. Lessened oil imports and stabilized oil prices caused by the availability of alternative sources of transportation fuels will also improve our international balance of trade.

- **Continue U.S. leadership role in clean energy technology.** By a recently published account, world trade in environmental controls has surpassed trade in armaments. Vision 21 will create the U.S. technology and expertise that will promote the export of fossil energy technology, equipment, and services. U.S. fossil energy/environmental industries will expand, new industries will be created, and there will be local, regional, and national benefits.
- **Provide the most certain route to achieving our energy, environmental, and economic objectives.** None

of the power and fuel subsystems currently being developed in the FE R&D program can *individually* meet the energy, environmental, and economic challenges of the future. Although each of these subsystems will be a substantial improvement on today's technology, the rapidly changing domestic and international situation requires that more be done. Vision 21 combines electricity and fuel-producing subsystems in a way that seeks to maximize thermal efficiency, minimize emissions of traditional pollutants, minimize cost, and can provide for CO₂ sequestration.

Vision 21 Fleet for the 21st Century



Vision 21 Technologies

A portfolio of key critical technologies contains two kinds of technologies: enabling and supporting. Enabling technologies are those upon which the subsystems, or modules, that form the building blocks of a Vision 21 plant

depend. Some enabling technologies, like gasification and advanced combustion, are already under development and are being demonstrated in the Clean Coal Technology Demonstration Program. Others, such as gas separation membranes, require major improvements of existing technologies. Supporting technologies are cross-cutting technologies that are critical to Vision 21 but are also important in other applications.



Enabling Technologies

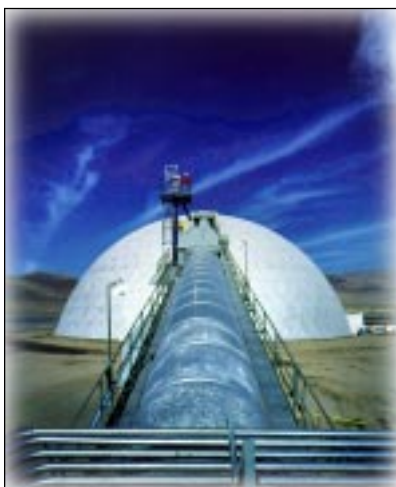
- Gas separation, e.g., membranes for separating oxygen from air and hydrogen from syngas
- High-temperature heat exchangers
- Fuel-flexible gasification
- Gas stream purification
- Advanced low-NO_x combustion systems
- Fuel-flexible turbines
- Fuel cells
- Fuel and chemical synthesis reactors, and improved catalysts

Supporting Technologies

- Materials and components
- Virtual demonstration - advanced computer models that link the Vision 21 subsystems and simulate the total plant
- Advanced controls and sensors
- Modularization - Vision 21 plants may be built from modules that will be available in several fixed size ranges; modular design and construction will maximize shop fabrication, minimize expensive field construction, and maintain flexibility in design

Vision 21 Program Elements

Vision 21 is seen as a long-range, cost-shared, industry-driven R&D program designed to produce public benefits from the present to 2010-2015 and beyond. Planning is a cooperative effort of the DOE Office of Fossil Energy and the Federal Energy Technology Center (FETC), with input from other DOE organizations, national laboratories, universities, and private industry. The Vision 21 program consists of five program elements.



Element 1. *Management Plan*

Includes preparation of an R&D road map, acquisition (solicitation process), and program and project management.

Element 2. *Systems Analysis and Integration*

Includes computer software development, definition of Vision 21 system configurations, economic and market analysis, virtual demonstration, and systems integration.

Element 3. *Enabling Technologies*

The scale of R&D activities will range from laboratory- and bench-scale to pilot-scale, including facilities needed to demonstrate the feasibility of prototype- and commercial-scale plants.

Element 4. *Supporting Technologies*

Supporting technologies include materials and components, virtual demonstration, and advanced controls and sensors.

Element 5. *Vision 21 Plant Design*

Includes component/subsystem design, prototype plant design, and commercial plant design.

Systems Integration

Developing the know-how to best configure and link the subsystems that constitute each Vision 21 plant is the goal of systems integration. High thermal efficiency requires “tight” integration of subsystems in order to achieve maximum heat recovery, maximum utilization of feedstocks, and minimum production of disposables. However, tight integration leads to complex interdependencies among the various subsystems, leading to serious startup, control, and reliability issues. Systems integration studies address systems engineering,

dynamic response and control, and industrial ecology. Making systems integration a major effort in the Vision 21 program will help to ensure the safe, reliable, economic operation of Vision 21 plants.

Vision 21 Business Strategy

- **Solicit** Vision 21 concepts and evaluate.
- **Identify** R&D needs and investment priorities.
- **Establish** industry/government partnerships and consortia.
- **Establish** resources and cost-sharing requirements.
- **Conduct** R&D using a phased approach and cooperative agreements.
- **Spin-off** products.

Vision 21 Products

Major products of the Vision 21 program include the following:

- low-cost oxygen and hydrogen separation technology;
- gas purification/cleaning technology;
- better catalysts for producing fuels and chemicals from low-valued raw materials;
- more efficient, lower-cost environmental control technology;
- improved, low-cost manufacturing techniques for high-technology components;
- improved materials for service under aggressive, high-temperature conditions;
- improved design and simulation tools, including virtual demonstration computer simulation software;
- engineering designs for components and subsystems;

- engineering designs for prototype (small commercial) plants; and
- engineering designs for large commercial plants.

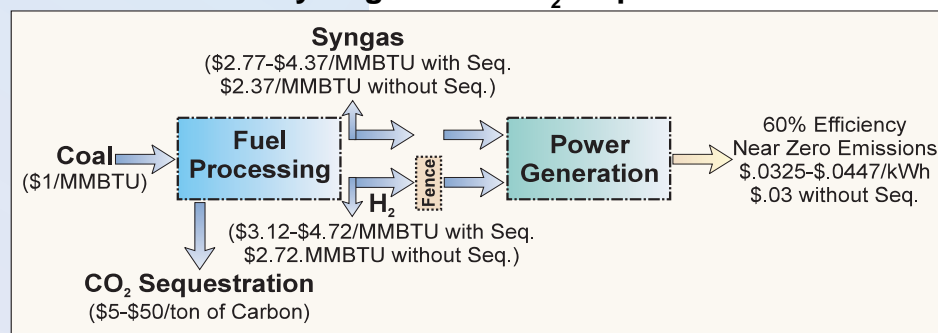
Construction of Vision 21 prototype and commercial-scale plants will be left to private industry; timing will depend upon prevailing economic conditions and market forces. DOE's role will be to develop the database needed for the design and construction of Vision 21 plants and to facilitate its transfer to industry.

Meeting the Challenge

Achieving the performance and cost goals set for Vision 21 technology will be a major challenge, but one that a cooperative industry/government partnership can meet. The result will be fossil-fuel based energy plants with unprecedented levels of efficiency and environmental performance. A successful Vision 21 program will help

ensure that our nation continues to have the plentiful supply of clean, low-cost energy essential to robust economic growth.

Coproduction of Electricity and Low Cost Syngas and/or Hydrogen with CO₂ Sequestration*



*Assumes success in developing key advanced technologies. Costs shown are approximate.

For more information, contact:



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